

EAST WINDS ON THE NORTH PACIFIC COAST¹

By EDWARD LANSING WELLS, Meteorologist.

[U. S. Weather Bureau, Portland, Oreg., Sept. 12, 1923.]

To a resident of the North Pacific coast region, especially of the lower Columbia Valley west of the Cascade Mountains, the term "east wind" carries with it a meaning which is distinct. You may talk to him of the west wind or the south wind and he will understand that you are just talking about the wind and the direction from which it is blowing, but when you mention the east wind he knows you are talking not merely of wind, but of a kind of weather.

This is not because the east wind always brings the same kind of weather, for it does not. Sometimes it is very cold and sometimes it is very hot. Sometimes it is very dry and sometimes it is very wet. It may bring snow or sleet, or glaze, which is least welcome of all, or it may dry the forests till fires become unmanageable. Whatever it does bring, however, is likely to be abnormal and extreme. If it is cold, it is not only colder than any other wind experienced in this section but it is also more penetrating. If it is hot, it is unusually hot. If the relative humidity is low, it is lower than in any other wind. If it is accompanied by rain, it is likely to be a rain storm that will be remembered. If it brings snow, it is more nearly like a blizzard than anything else that is known in this region of normally mild and equable climate.

One reason for the distinction accorded to the east wind in the minds of residents of this section is that it is an unusual occurrence and the weather that accompanies it is so very unlike that which is normally experienced.

The phenomenon treated here under the title "east wind" occurs throughout the entire North Pacific coast region, but, owing to the rugged topography of this region, the wind in some sections may come from the northeast or north or even from the southeast, although the ordinary southeast wind is something entirely different.

The east wind, as might be expected, is most prevalent along a line extended westward from the Columbia River Gorge, which is the only break in the great mass of the Cascade Range, and in the Straits of San Juan de Fuca. Local topography has a decided effect upon the direction of this wind and to some extent affects its results. The Weather Bureau office at Portland is located in the principal business area of the city, on the flat between the Willamette River on the east and north and the hills that rise on the west and south to a height of about 1,000 feet. The writer lives in Rose City Park, nearly 4 miles east-northeast from the office. At that point the wind may be coming directly from the east while at the office it is southeast.

The climate of the region west of the Cascade Mountains under ordinary conditions, is largely controlled by the marine influence. When so controlled it is characterized by equable temperature, with considerable cloudiness and rain in winter and pleasant, bracing weather in summer, with a comparatively low evaporation rate. When the east wind blows it brings over the Cascades and through the Columbia River Gorge a supply of air which has the characteristics of a continental climate. In summer, and sometimes in winter, this body of air is deep enough to cause the continental characteristics to prevail in all respects. At times, however, in winter

the layer of imported air is shallow and underruns a current of warm, moist air from the ocean, and when this happens something out of the ordinary is sure to follow.

The east winds are, roughly, of three types. All three are anticyclonic, depending on the existence of a high pressure area somewhere over the northern Rocky Mountain region. They are the hot, dry wind of summer; the cold, dry wind of winter, which may be followed by rain or snow; and the cold, wet wind of winter, which may be accompanied by rain, sleet, or glaze.

The hot winds are ordinarily confined to the summer months, but dry east winds, carrying temperature above normal, have been known to occur as early as the last week in February and as late as the first week in October. This wind is dreaded by those who are interested in forest

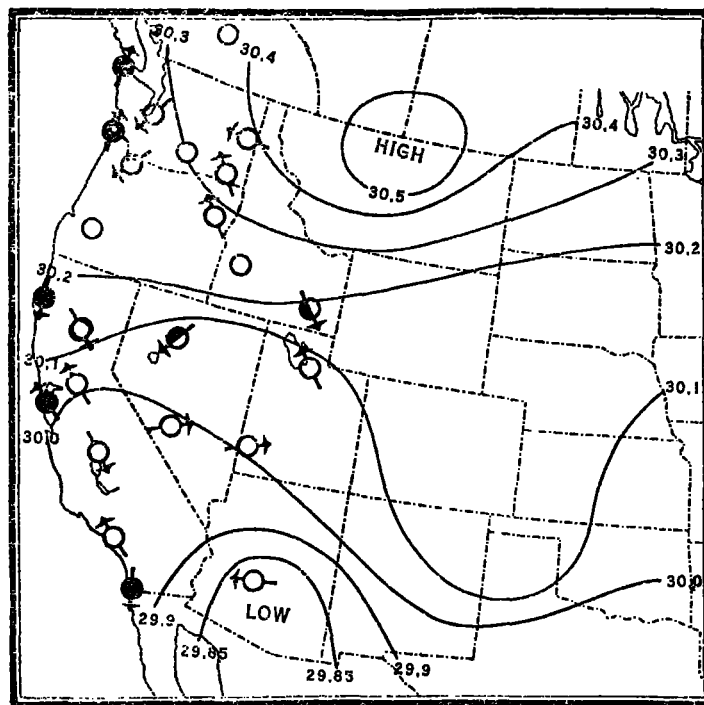


FIG. 1.—Weather map for May 29, 1922.

preservation, for the low relative humidity developed increases the forest-fire hazard many fold. Such a wind occurs when a large area of high pressure drifts slowly eastward from the North Pacific coast, increasing somewhat as its center reaches the northern Rocky Mountain region. The most striking example of this in recent years was that which occurred in the last five days in May, 1922. The pressure distribution giving rise to this wind is shown in Figure 1, which is a copy of the daily weather map for May 29, 1922. During the period covered by this wind the temperature was unusually high, in some cases the highest of record for May, the relative humidity was very low, reaching a minimum of 13 per cent at Portland on the 30th, and the wind movement was strong and well sustained, reaching a maximum of 48 miles an hour at Tatoosh Island, Wash., on the 28th. Prevailing directions at Weather Bureau offices in western Oregon and Washington during this period were as follows: Tatoosh Island, Wash., northeast; Port Angeles, Wash., east; Seattle, Wash., north; North

¹ Prepared for the American Meteorological Society Meeting at Los Angeles, Calif., September 17-19, 1923.

Head, Wash., east; Portland, Oreg., east; Roseburg, Oreg., north. During this period many forest fires were started, and had another such east wind occurred later in the season great loss would have resulted. Fortunately these winds occur only at considerable intervals.

Undoubtedly these hot east winds of the summer months are of the Foehn type, and are somewhat warmed

6 and 7, 1915. The temperature during this period was generally above normal, notwithstanding the lateness of the season, and some very low relative humidity records were made, the lowest being 24 per cent at Roseburg.

Figure 4 shows the pressure distribution during the occurrence of an east wind of the second type, which is most common, occurring usually several times every

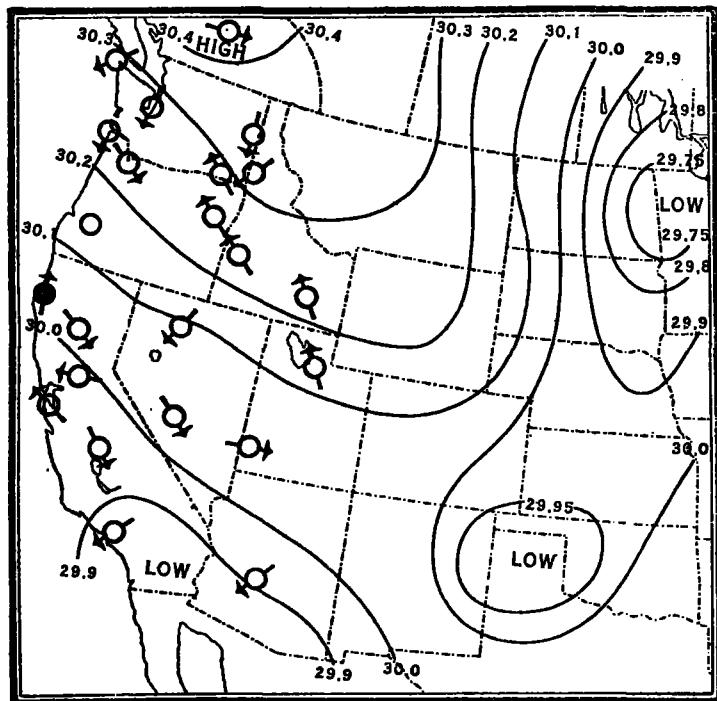


FIG. 2.—Weather map for October 6, 1915.

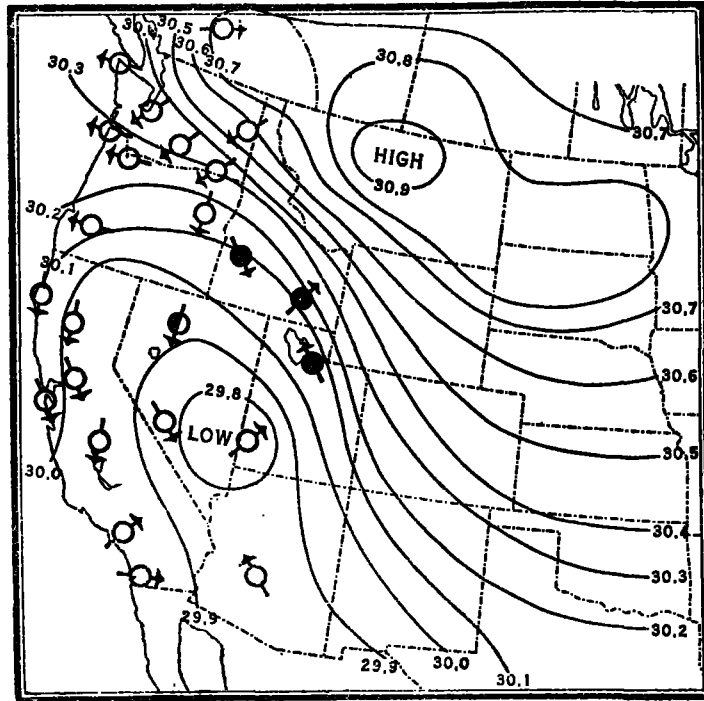


FIG. 4.—Weather map for January 30, 1918.

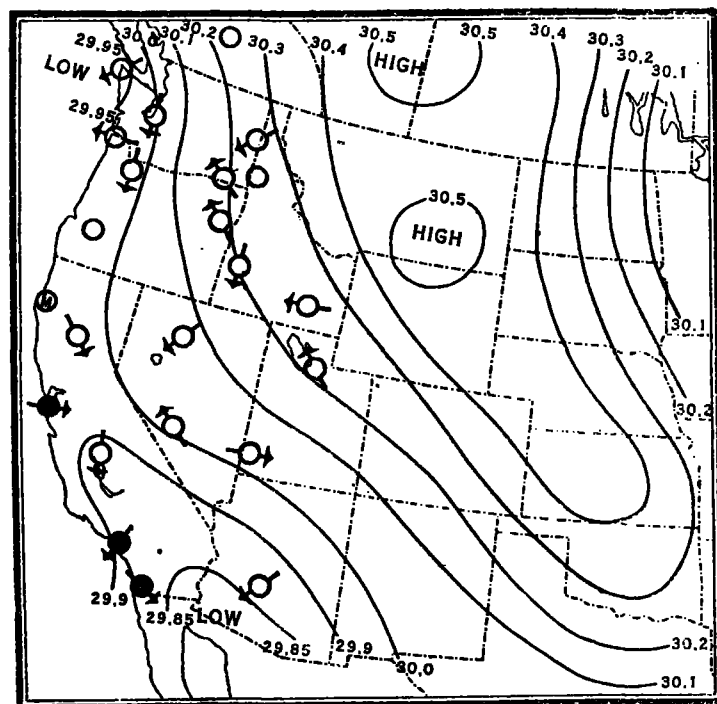


FIG. 3.—Weather map for October 7, 1915.

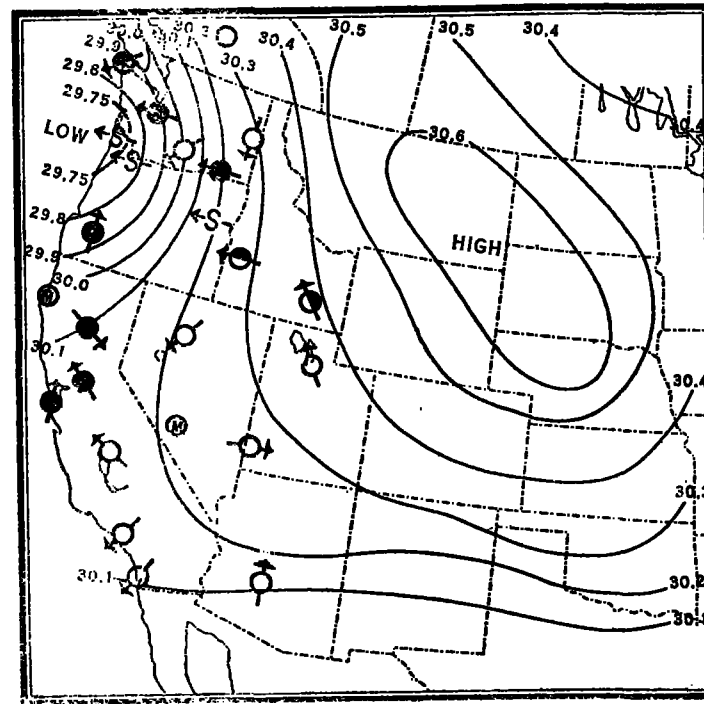


FIG. 5.—Weather map for December 9, 1919.

by compression as they descend from the high plateau east of the Cascades to the lower lands toward the ocean, but no precipitation occurs as they cross the mountains, and their heat is largely the result of insolation under the bright sky of the intermountain region.

Figures 2 and 3 show the pressure distribution at the time of the occurrence of a warm, dry wind on October

winter. In this type the Foehn process is doubtless active, for although the air is much colder than that ordinarily overlying this region, it is usually dry to begin with, and is really considerably warmer than when it left the plateau region. The sensation of cold produced by such a wind is altogether out of proportion to the actual temperature, for often this is only slightly below freezing.

This is due in part to its habit of blowing without cessation for several days (in part to the fact that it is dry while the normal winter air in this region is moist), and in part to the fact that while it is not extremely cold the temperature is much lower than is experienced under other conditions. Other things being equal, dry winter air does not seem so cold as does humid air. In the winter of 1917-18 no freezing weather was experienced in Portland until January 30. Under the influence of an east wind the temperature fell below freezing on the afternoon of that day, and did not rise above freezing again until the wind changed to the northwest on February 1.

The winter east wind usually begins with clear sky and dry air. In the instance referred to in the preceding paragraph the relative humidity fell to 37 per cent on

from the Willamette Valley to Puget Sound, and the low humidity continued at Seattle on the 9th.

The coldest month of record at Portland was January, 1888. The cold weather at that time does not seem to have been the result of east wind, but seems to have been a part of a great cold wave covering most of the country. However, the second coldest month of record was January, 1916, in which the wind at Portland blew from the east 47 per cent of the time. The chart² representing the average pressure for that month shows high pressure east of the Rocky Mountains and low pressure extending from the Washington coast to Arizona.

The third type of east wind is the type which results from such pressure distribution as is shown on Figure 6. In this type a cold current coming from a center of high pressure somewhere in the northern Rocky Mountain region meets a warm, moist, southerly current coming from the ocean. The meeting place is somewhere in a trough-like depression that separates the two areas, which is not always well defined. The cold current, being the heavier, usually undercuts the moist, warm current. The degree to which this moist current is cooled by this process determines the character of the precipitation that results. If the precipitation forms as rain it may be frozen into pellets of ice as it falls through the cold current, or it may become overcooled so that it freezes immediately on striking. The place most favorable for a deposit of glaze is in and near the Columbia River Gorge. The storm of February 1, 1916, which is the date of Figure 6, was unusually severe, causing immense damage to overhead wires in Portland and vicinity.

Sometimes an east wind of this type is attended by very heavy precipitation. This occurred in the storm of November 19-22, 1921, when the four-day precipitation in northwestern Oregon ranged from 6 to 13 inches.³

The east wind seldom reaches destructive force, but is very persistent, blowing for a day or two, or perhaps longer, without cessation. For the year 1922 at Portland the average hourly wind movement, all directions considered, was 6.1 miles an hour, but the average velocity of the east wind was 7.9 miles an hour.

In Table 1 there are assembled data for six regular Weather Bureau stations in western Oregon and western Washington for 27 selected dates on which conditions were favorable for east wind. It will be noted that some easterly or northerly wind occurred on every one of these dates, but that it frequently did not occur at all the stations at the same time. This table shows clearly the difficulty of making a general wind forecast apply to a particular locality, and emphasizes the need for a special study of local winds and their effects, in order that fire weather warnings may be localized as frost warnings are now localized, and that other interests affected by the east wind may be given better advance knowledge of its occurrence.

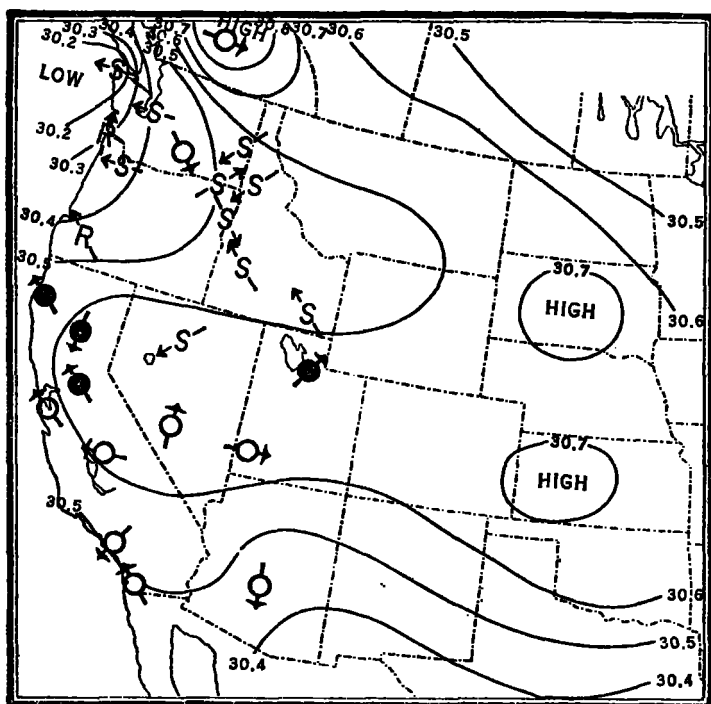


FIG. 6.—Weather map for February 1, 1916.

January 31. Quite often, however, snow begins to fall before the wind changes. Most of the few heavy snowfalls that have occurred in this section have been accompanied by east wind. One of the worst snowstorms ever experienced in Portland was that of December 9 and 10, 1919, when snow accumulated to a depth of more than a foot, and traffic was completely blocked. This snowfall was accompanied by a strong east wind, and was followed by the lowest temperatures since the historic cold spell of January, 1888. The pressure distribution on the first day of this storm is shown in Figure 5. On December 8, when the wind began, low relative humidity prevailed

² Chart 7, Vol. 44, Mo. WEATHER REV.

³ Mo. WEATHER REV. 49: 661.

TABLE 1.—Effect of "east-wind" conditions in various sections of Oregon.

	1914		1915				1916				1918				1919			1921			1922						
	July.		Feb. 8.	July.		October.		January.			February.			January.		Feb. 1.	December.			November.			May.				
	28	29		19	20	6	7	26	27	28	1	2	27	30	31		8	9	10	19	20	21	27	28	29	30	31
Maximum velocity of wind:																											
Tatoosh Island, Wash.....	19	19	42	44	43	40	44	41	50	41	58	88	36	48	47	48	39	70	62	56	64	66	43	48	32	39	46
Port Angeles, Wash.....	9	9	15	12	9	13	11	30	35	30	27	49	11	25	12	12	12	32	29	10	17	12	9	27	7	9	9
Seattle, Wash.....	18	18	26	18	18	16	11	23	19	13	12	19	27	33	15	19	23	22	19	8	21	34	19	18	17	18	17
North Head, Wash.....	35	26	75	25	27	24	29	36	20	22	46	54	18	24	33	34	26	34	19	48	29	84	15	23	30	27	29
Portland, Oreg.....	14	11	30	14	10	23	17	16	23	28	11	22	15	23	29	21	18	30	31	18	10	22	26	26	19	22	19
Roseburg, Oreg.....	9	8	26	9	9	6	5	8	9	12	8	12	10	10	6	13	3	18	18	13	17	12	8	15	14	8	11
Direction of maximum velocity:																											
Tatoosh Island.....	W.	S.	E.	E.	E.	NE.	NE.	E.	NE.	E.	E.	NE.	W.	E.	E.	E.	NE.	NE.	NE.	NE.	N.	N.	S.	NE.	E.	E.	NE.
Port Angeles.....	N.	N.	SE.	NE.	NE.	SE.	SE.	NE.	NE.	S.	E.	NE.	SE.	NE.	SE.	SW.	NE.	NE.	NE.	N.	N.	SW.	S.	NE.	NW.	N.	S.
Seattle.....	N.	N.	E.	N.	N.	NW.	N.	N.	S.	E.	NE.	NE.	S.	NW.	E.	E.	E.	E.	E.	SW.	SW.	S.	N.	E.	NW.	N.	S.
North Head.....	NW.	NW.	SE.	NW.	NW.	E.	SE.	W.	SE.	E.	S.	S.	NW.	E.	E.	E.	E.	E.	E.	SE.	SW.	S.	E.	E.	NE.	N.	NE.
Portland.....	N.	NW.	SW.	NE.	N.	NE.	E.	SW.	E.	E.	E.	E.	E.	E.	E.	E.	E.	E.	E.	SE.	E.	S.	E.	E.	NE.	N.	NE.
Roseburg.....	N.	NW.	SE.	N.	NW.	NW.	W.	SW.	N.	S.	E.	S.	N.	NW.	E.	SW.	NW.	SE.	W.	S.	S.	SW.	N.	NW.	N.	N.	N.
Number hours north-to-east winds:																											
Tatoosh Island.....	6	0	23	24	12	24	19	14	24	24	24	12	22	24	11	24	24	24	24	24	20	24	24	2	24	18	12
Port Angeles.....	6	7	7	11	12	7	7	10	23	24	24	6	11	6	1	6	23	14	5	7	2	12	14	5	12	12	12
Seattle.....	23	17	14	19	11	19	13	8	24	24	13	23	10	12	0	0	24	24	14	19	24	16	19	24	16	24	23
North Head.....	0	0	18	21	17	24	9	2	24	21	5	11	9	22	24	14	21	24	24	6	15	0	17	22	12	18	6
Portland.....	15	11	15	9	8	15	16	6	24	23	24	17	17	12	22	8	9	23	23	9	14	14	14	24	21	24	19
Roseburg.....	11	8	7	8	5	5	6	4	11	2	1	4	5	10	9	5	12	6	1	0	0	2	12	6	14	16	12
Departure from normal temperature:																											
Tatoosh Island.....	-2	-2	+9	+3	+7	+1	+3	-11	-11	-12	-8	-7	+6	-7	-6	-3	-10	-18	-18	-9	-13	-5	+1	+12	+8	+7	+15
Port Angeles.....	-8	-7	+5	+7	+5	-1	0	-12	-8	-11	-6	-7	+2	-9	-7	-2	-14	-18	-18	-12	-12	-12	-3	+3	+6	+8	+9
Seattle.....	-2	0	+12	+7	+12	+1	+5	-11	-9	-13	-10	-10	+6	-8	-10	-9	-12	-18	-20	-12	-13	-5	+1	+11	+13	+16	+16
North Head.....	-4	-4	+9	+2	-3	+7	+6	-9	-14	0	-4	+7	-7	-11	-4	-13	-20	-21	+1	0	+3	+9	+13	+1	+17	+12	+12
Portland.....	0	+3	+12	+10	+16	+2	+8	-9	-15	-11	-10	+4	-6	-14	-13	-14	-22	-25	-3	-11	+1	+3	+13	+11	+15	+17	+17
Roseburg.....	+1	+5	+6	+7	+11	+3	-4	-10	-11	-13	+1	+8	+3	+1	-5	-1	-11	-4	0	+4	+10	+13	+4	+10	+7	+14	+13
Relative humidity, 8 p. m., 75th meridian time:																											
Tatoosh Island.....	85	91	71	59	81	70	73	84	79	63	100	67	65	68	68	82	64	55	49	72	65	99	74	33	97	59	60
Port Angeles.....	71	56	74	38	62	52	59	87	70	83	100	99	71	94	66	96	86	86	92	98	94	96	53	49	58	49	40
Seattle.....	42	32	50	37	38	58	39	93	65	42	97	100	27	46	41	100	36	36	97	92	99	100	37	24	23	29	22
North Head.....	86	92	84	84	92	28	84	83	78	83	100	95	58	80	70	86	38	79	77	100	100	96	30	26	91	54	92
Portland.....	29	17	23	22	22	26	26	76	52	49	100	92	21	47	37	87	54	85	90	92	95	88	26	24	22	13	16
Roseburg.....	23	23	41	24	32	29	24	58	89	95	88	73	34	75	55	78	81	81	85	64	90	75	18	22	27	17	30
Precipitation:																											
Tatoosh Island.....	0	0	.25	T.	.06	0	0	.19	.13	0	1.48	.59	0	0	.11	.57	0	0	0	T.	T.	1.11	0	0	0	0	0
Port Angeles.....	0	0	.01	0	0	0	0	.15	0	.15	1.14	2.52	0	0	0	T.	0	0	T.	.01	.32	.29	.43	0	0	0	0
Seattle.....	0	0	T.	0	0	0	0	.05	0	T.	1.02	1.30	0	0	0	.48	0	0	0	.07	.44	.37	1.06	0	0	0	0
North Head.....	0	0	.02	0	0	0	0	.09	.13	0	3.01	2.24	0	.01	0	.62	.12	.23	.11	1.32	1.10	.47	0	0	0	0	0
Portland.....	0	0	T.	0	0	0	0	.19	0	.12	1.94	1.39	0	.01	0	.61	.01	1.10	.60	2.68	3.41	.62	0	0	0	0	0
Roseburg.....	0	0	.03	0	0	0	0	.16	.13	.20	.42	.24	0	.01	0	.52	0	.22	1.83	.54	1.07	1.27	0	0	0	0	0

NOTE ON TRADE WINDS IN HAWAII.¹

By THOMAS ARTHUR BLAIR, Meteorologist.

[Weather Bureau Office, Honolulu, T. H., Aug. 28, 1923.]

The Hawaiian Islands offer an unexcelled opportunity for a study of the characteristics of the trade winds. They are continuously within the trade-wind belt, and in summer not far from its center; their area is considerable; and they are 2,000 miles from the nearest continental coast. The trade winds are largely predominant throughout the islands for all seasons, but there are occasional reversals in winter, and, also, though less frequently, in summer. The latter are less well developed and usually persist for but a few hours, whereas the winter reversals may persist for several days.

It is intended to present here merely a brief preliminary note on the depth of the trades, as shown by pilot-balloon flights made by the meteorological section of the Signal Corps at Schofield Barracks, island of Oahu, Territory of Hawaii; latitude 21° 30' N.; longitude 158° 4' W.; elevation, 262 meters (860 feet). The records of 197 flights have been examined. These were made twice or more daily, with various exceptions, during the period from April 2 to August 24, 1923. Of these, 12 show westerly winds within the first 250 meters, 41 winds with a southerly component, and the remainder are from the northeast quadrant. Only 32 of the balloons were observed to an elevation of 5,000 meters. The number of times each direction was observed at the different elevations during these 32 flights is entered in the accompanying table.

The most frequent direction, from the surface to 3 kilometers, inclusive, is east; at 4 kilometers it is east-southeast; and at 5 kilometers, southwest. Of the 24 observations at 6 kilometers, 14 had a westerly com-

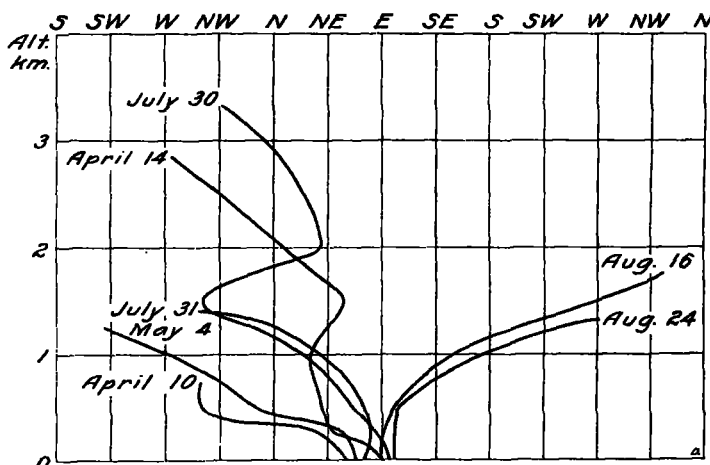


FIG. 1.—Course of 7 pilot-balloon flights showing shallow trade winds made at Schofield Barracks, Oahu, Hawaii, by the meteorological section, Signal Corps, United States Army, April to August, 1923.

ponent; 9, easterly or northerly, and 1 was calm. At 7 kilometers, 12 out of 18 were from directions between south and west, and 6 between north and east;

¹ Read by title at meeting of American Meteorological Society, Los Angeles, Calif., Sept. 15, 1923.